Gobiidae

Kevin Fleming

The Gobiidae family is one of the largest fish families. Found worldwide, most of its species are small and benthic or epibenthic. Six species of gobies were commonly collected in the San Francisco Estuary from 1980 to 1995: the bay goby, *Lepidogobius lepidus;* the arrow goby, *Clevelandia ios;* the cheekspot goby, *Ilypnus gilberti*; the yellowfin goby, *Acanthogobius flavimanus*; the shimofuri goby, *Tridentiger bifasciatus*; and the chameleon goby, *Tridentiger trigonocephalus.* The bay, arrow, and cheekspot gobies are native to the estuary; whereas the yellowfin, shimofuri, and chameleon gobies have all been introduced from Asia.

This chapter will discuss only the bay, yellowfin, and chameleon gobies. The data for the arrow gobies was previously reported (CDFG 1987). Very few cheekspot and shimofuri gobies were collected by the otter trawl. The longjaw mudsucker, although common in the estuary, was rarely collected. Its habitat, euhaline mud flats and salt ponds, was not well represented in the sampling program.

Bay Goby

Introduction

The bay goby is common in bays and estuaries from Baja California to Vancouver Island, British Columbia (Miller and Lea 1972). It is benthic and is often found living commensally with burrowing invertebrates (Grossman 1979b). It may live more than 7 years (Grossman 1979a), but based upon length frequency data, its life span may be as short as 2 to 3 years (CDFG 1987). Some individuals reach sexual maturity at the end of their 1st year and the rest by the end of their 2nd year (Grossman 1979a).

Spawning takes place throughout the year and peaks between June and October (CDFG 1987). The larvae are concentrated near the Golden Gate Bridge and Angel Island (Wang 1986). They are planktonic for 3 to 4 months (Grossman 1979a) and descend to the bottom as juveniles at about 25 mm TL (Wang 1986).

Methods

The otter trawl data were used for the descriptions of length, abundance, and distribution. The abundance index period was February through October. Fish were not separated into age classes.

Results

Length

The bay goby reached adult size (about 90 mm) within 1 year, suggesting that it may also complete its life span within 1 year. Most of the smallest bay gobies grew large enough to recruit to the otter trawl in winter and early spring. The fastest growth occurred during spring, particularly in March and April (Figure 1). By summer, as they reached the end of their 1st year, they had reached nearly the maximum size.

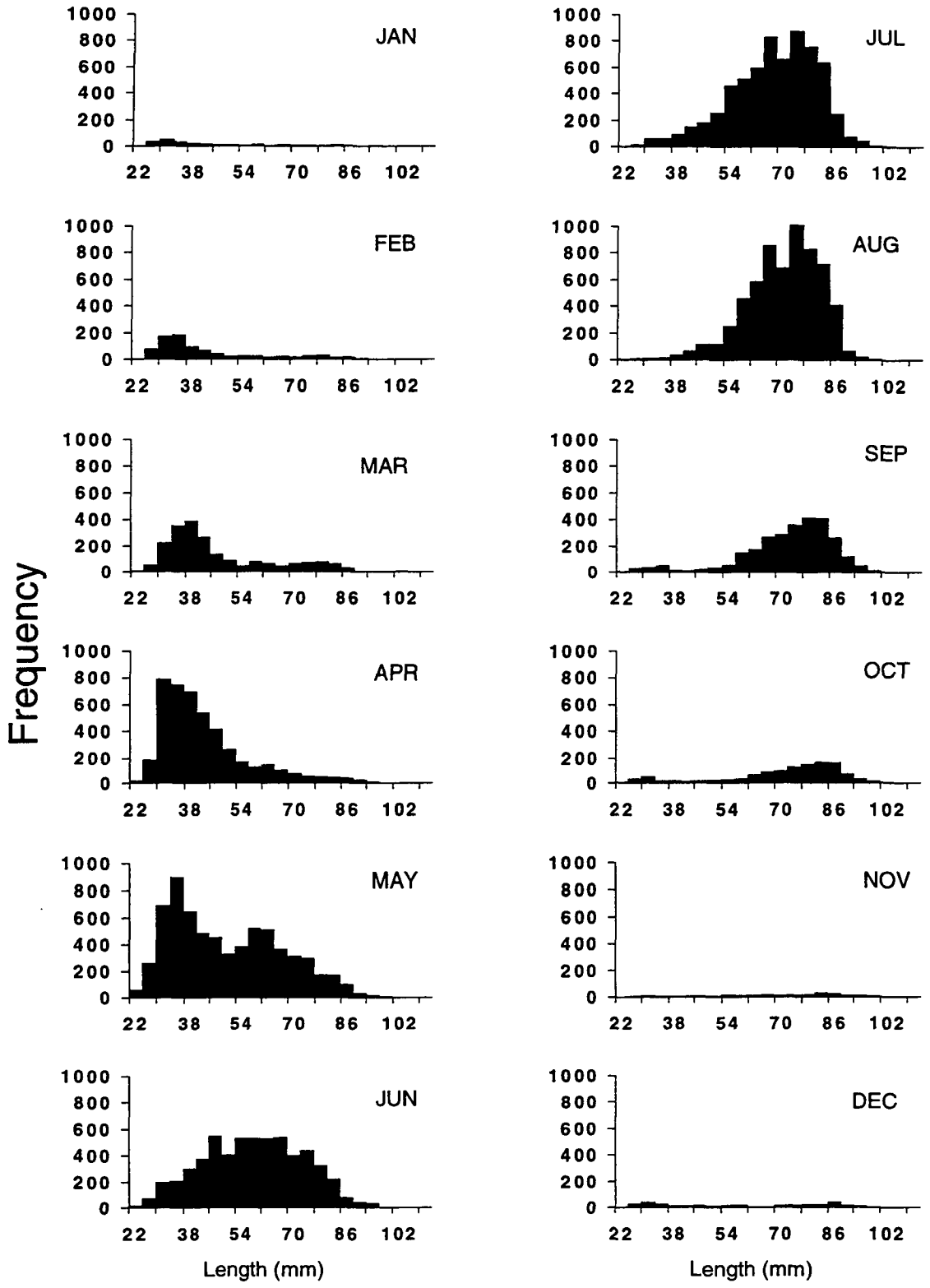

Figure 1 Length distribution of bay gobies by month from 1980 to 1988

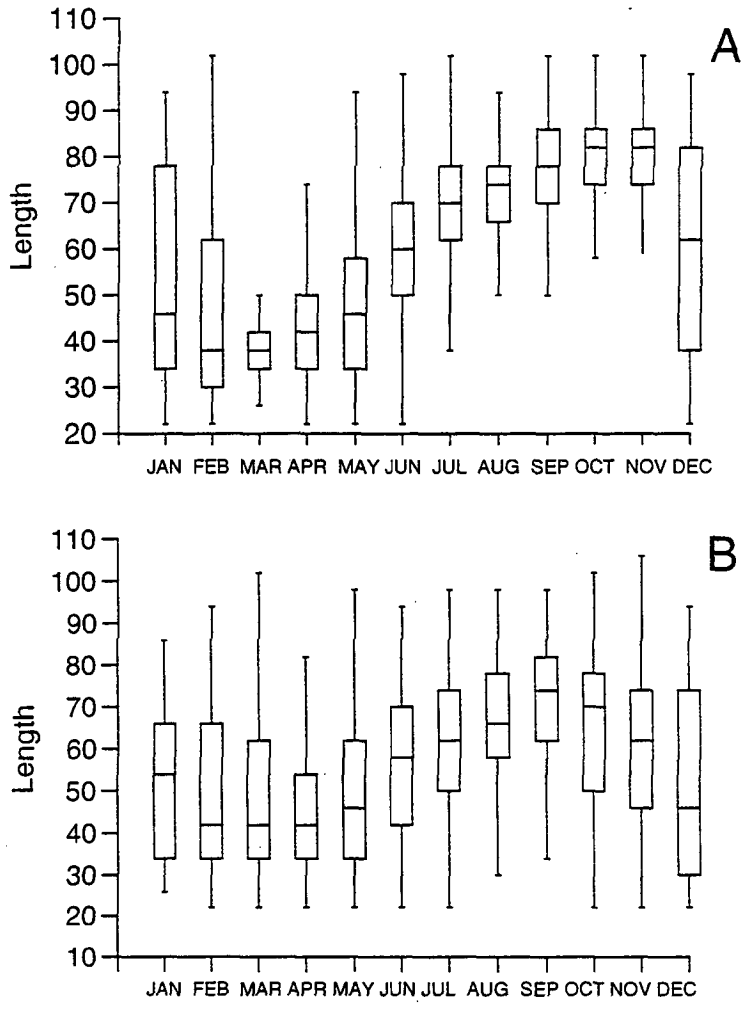

Figure 2 Length distribution of bay gobies by month in (A) wet years and (B) critical years

The annual age structure was affected by outflow. During wet years, small fish (<40 mm) were present primarily in winter and spring. Larger fish (>60 mm) were most abundant in summer and early fall (Figure 2). This pattern differed during dry years when both small and large fish were collected throughout the year.

Abundance

Abundance was highest in 1991 and lowest in 1985 (Figure 3, Table 1). The 4 lowest abundance years were in the early and mid-1980s. Abundance did not appear to be related to outflow as both dry and wet years (see Salinity and Temperature chapter, Table 1) had either low or high abundance. However, outflow may have influenced the seasonal pattern of abundance. During wet years, the monthly abundance indices peaked only once per year in late summer. But during dry years, the monthly indices showed 2 modes, the 1st in spring and the 2nd in midsummer (Figure 4).

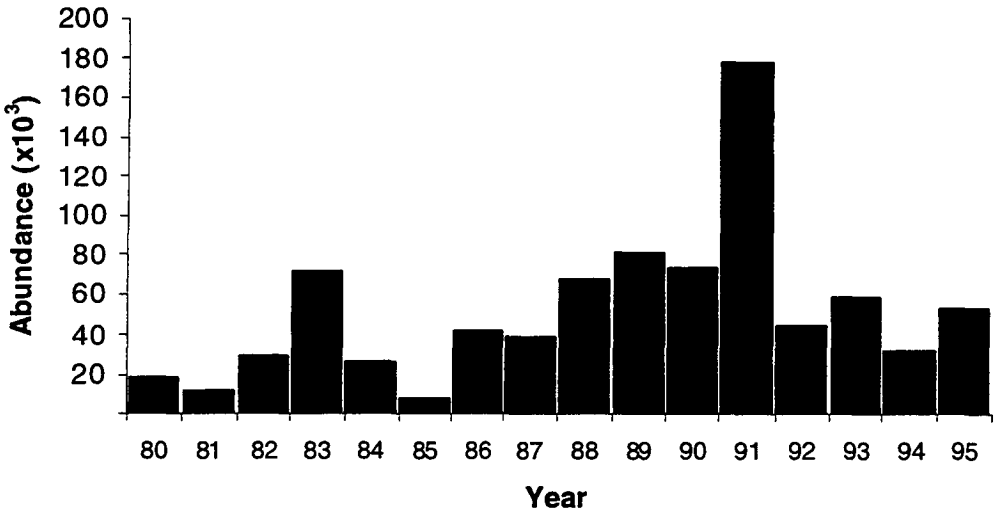

Figure 3 Annual abundance of bay goby

Table 1 Monthly abundance indices of bay gobies captured in the midwater trawl from 1980 to 1995. The last column is the annual index, the mean abundance from February to October. The bottom row is the average seasonal abundance from 1981 to 1988.

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Index*
1980		4788	6229	11318	13544	108158	12390	2532	2209	1026	2290	783	18022
1981	338	562	1970	16679	11232	6919	22230	37163	2630	7208	0	892	11844
1982	6225	850	36783	71633	55582	41107	4221	29704	23578	1862	1359	899	29480
1983	6016	5214	1667	90380	74092	48982	35228	383764	368	6901	2845	7095	71844
1984	2613	3297	3362	22850	18160	43830	87949	16068	21217	12364	328	1102	25455
1985	189	3937	816	411	3109	11156	10039	23690	1554	20148	4346	1255	8318
1986	1099	647	14845	12510	30296	21794	121092	141478	30490	5840	2092	3379	42110
1987	1867	5122	36118	3004	10265	32714	61403	68591	85801	48638	25367	29988	39073
1988	2787	2101	5342	136806	244439	54358	148078	10223	9474	424	4107	17840	67916
1989	35945	52260	40010	53216	135715	110777	114733	64779					81641
1990		24688	53104	38151	93611	155562	91647	50663	117376	34874			73297
1991		25673	107768	319502	291601	109642	355563	234439	90651	74140			178776
1992		13108	58187	13101	120432	79119	26833	16971	33906	34946			44067
1993		23504	12445	9318	53529	111226	201754	90487	19866	9642			59086
1994		3364	10761	14013	24328	38437	13224	103947	76419	7464			32440
1995	17322	21492	50897	46102	107234	38574	95895		62361	944	11262	20298	52937
1981–1988	2642	2716	12613	44284	55897	32607	61280	88835	21889	12923	5056	7806	

Distribution

In general, bay gobies were most common in Central Bay, which had the highest CPUE in 11 out of 16 years (Figure 5). During these years, the Central Bay annual CPUE was usually more than double that of the other bays. Bay gobies were collected in the west delta only in 1980, 1989, and 1991, but they were present in Suisun Bay in all years, although the CPUEs were very low.

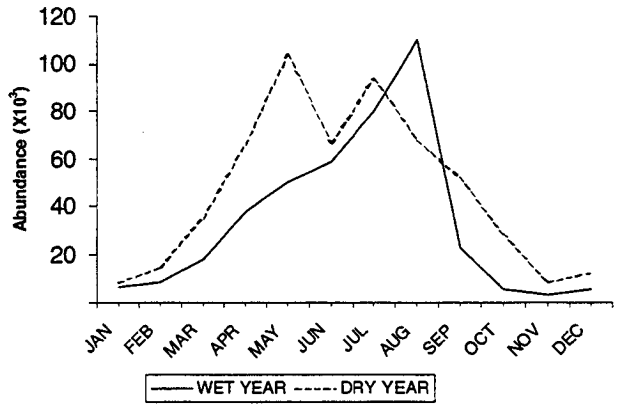

Figure 4 Seasonal abundance of bay goby by water year type from 1981 to 1988

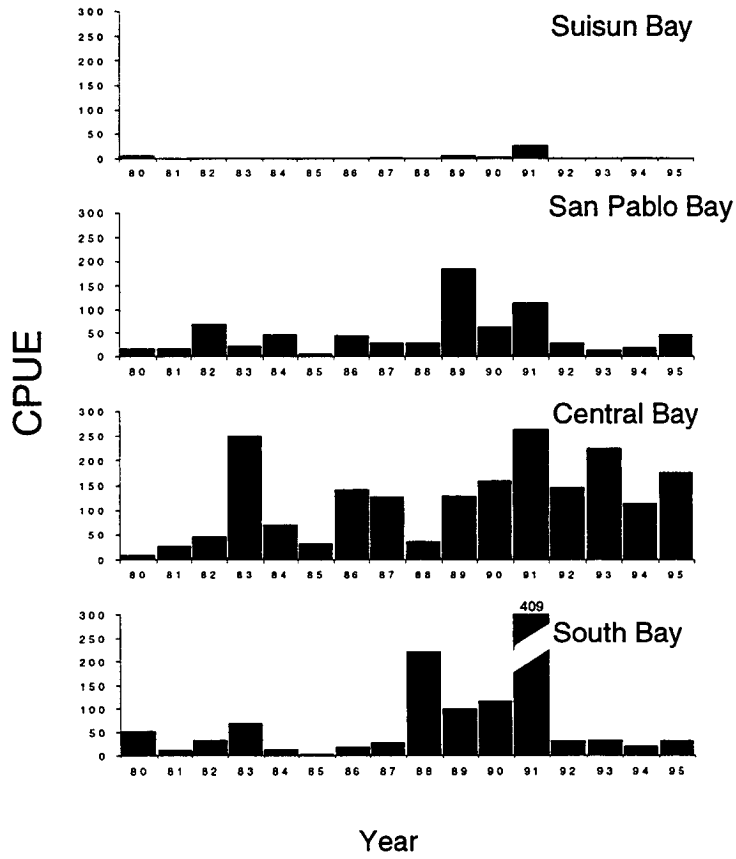

Figure 5 Annual bay goby distribution by region. Values are the average CPUE for February to October.

Bay gobies appeared to move between regions over the course of the year (Figure 6). In early spring, when most of the catch was made up of young bay gobies, the highest CPUE was in South and San Pablo bays. In late spring and summer, as the gobies matured, the center of distribution shifted from South to Central Bay, and in fall the CPUE decreased in all regions.

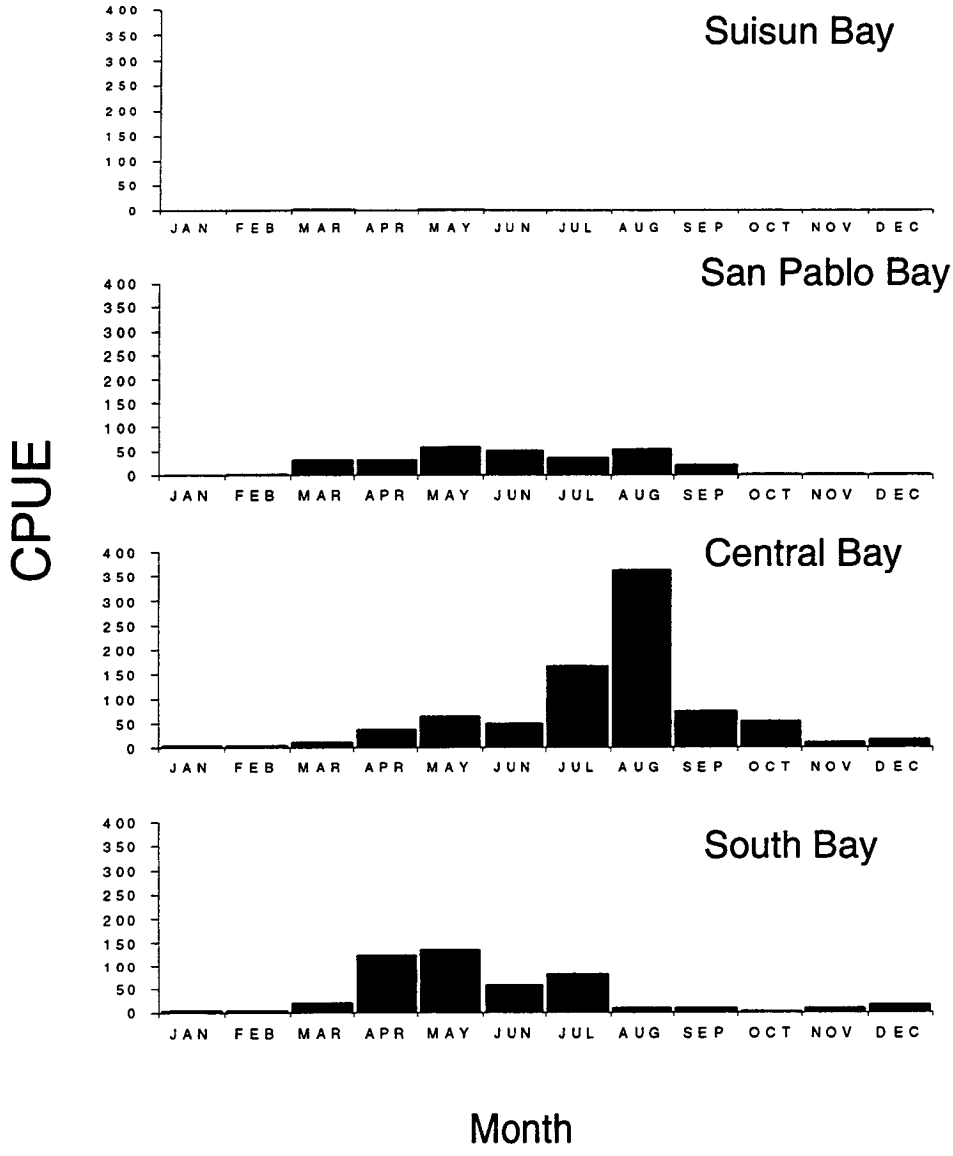

Figure 6 Seasonal bay goby distribution by region. Values are the average CPUE for 1981 to 1988.

Temperature and Salinity

Bay gobies remained in a fairly narrow temperature range, usually below about 18 °C (Figure 7). The salinity range was much more variable than the temperature range, particularly for the smaller gobies (see Figure 7). The salinity differences may be attributed to the reduced salinity in the estuary during winter and spring when small bay gobies were most common. However, bay gobies were mostly collected in upper polyhaline and euhaline salinities, at a mean of 27.5‰.

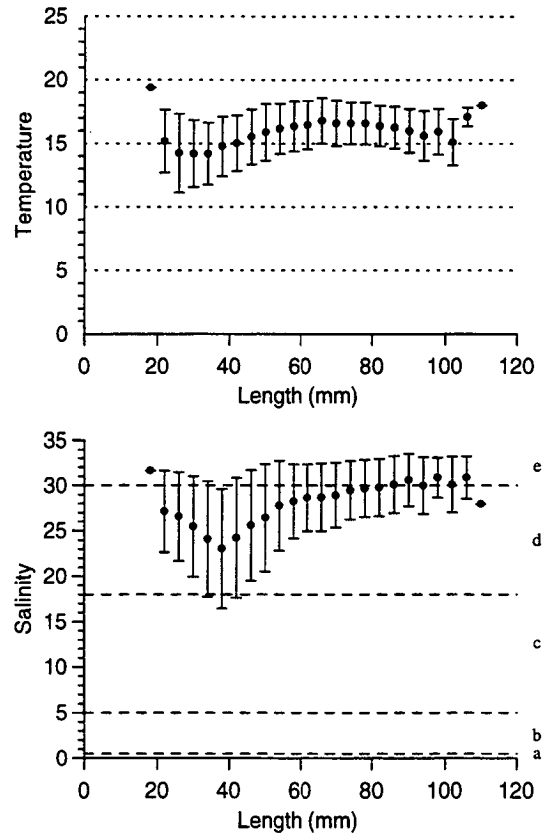

Figure 7 Temperature and salinity distributions of bay gobies by length. The dots are the means and the bars are 1 standard deviation. The horizontal lines on the salinity graph mark the boundaries of the Venice system ranges: (a) limnetic, (b) oligohaline, (c) mesohaline, (d) polyhaline, and (e) euhaline.

Discussion

The bay goby is the most abundant goby in the estuary. It is found primarily within the relatively cool, euhaline to upper polyhaline regions of Central, South, and San Pablo bays. Its range extends upstream from San Pablo Bay only in low outflow years. Of the 3 main areas used by the bay goby, San Pablo and South bays were used primarily as nursery areas, as few adults were collected in those bays. Mature fish were collected primarily in Central Bay, where the larvae were also found (Wang 1986).

Salinity and temperature appear to control their movements and distribution in the estuary. Abundance declined in South Bay when the average bottom temperature there increased above about 17 °C, which typically occurred by June. In San Pablo Bay the catches decreased by late fall when the average bottom salinity decreased to the lower polyhaline range.

River outflow directly affected reproduction, as seen in the seasonal recruitment pattern of juvenile bay gobies. During wet years, recruitment appeared to be restricted to June to October. During dry years, salinity remained high for a prolonged period and recruitment was prolonged, although the peak spawning still occurred in summer and fall.

Based upon the length frequency data, bay gobies appear to be short-lived and attain their maximum size within 1 to 2 years, rather than in the 7+ years reported in the literature (Grossman 1979a). The disagreement may be the result of sampling locations. Grossman conducted his research in Morro Bay and based his findings on the apparently slow growth rate of the bay goby (as shown in length frequency histograms) and the number of otolith annuli. A major difference between Morro Bay and San Francisco Bay is salinity, which does not fluctuate seasonally in Morro Bay as it does in San Francisco Bay. The constant high salinity in Morro Bay may have prolonged goby reproduction and generated multiple cohorts. These cohorts may have obscured the seasonal growth pattern and rates reported in Grossman (1979a), as they did in our data during the drought (see Figure 2). In addition, Grossman states that the occurrence of annuli is synchronous with reproduction. If so, then multiple spawnings would have led to an increased number of false "annuli" and an overestimate of age.

Yellowfin Goby

Introduction

The yellowfin goby is native to the estuaries of Japan, Korea, and northern China. It was accidentally introduced to the estuary in the late 1950s, was first collected in 1963, and is now well established (Brittan and others 1963, 1970). The yellowfin goby is a food item in Japan; in California, it supports a small, live bait fishery.

The yellowfin goby grows to about 240 mm, larger than any other California goby, native or introduced (Miller and Lea 1972), and may live from 1 to 3 years (Hoshino and others 1993). Males mature after their 1st year and females at the end of their 2nd year (Hoshino and others 1993). They move from fresh to saline waters to spawn from December to July (Wang 1986). The eggs are attached to the walls of Y-shaped burrows dug by males in the tidal flats (Dotu and Mito 1955) and are guarded by males until they hatch after 28 days (Dotu and Mito 1955). The pelagic larvae may use tidal currents either to maintain their position within the estuary or to ascend into fresher water areas during spring (Wang 1986). At about 15 mm, young gobies begin a benthic existence (Dotu and Mito 1955). Juveniles apparently prefer shallow water and can tolerate both low salinity and high temperature (Wang 1986).

Methods

Data from the otter trawl was used for the length-frequency histograms and to calculate the abundance indices. The index period was set from May to October to restrict it to age–0 fish.

Results

Length

Most yellowfin gobies caught in this survey were age 0. The smallest fish (about 20 mm) were first collected in spring and the largest, the age–1+ fish (about 175 to about 225 mm), were taken from late fall to early spring (Figure 8).

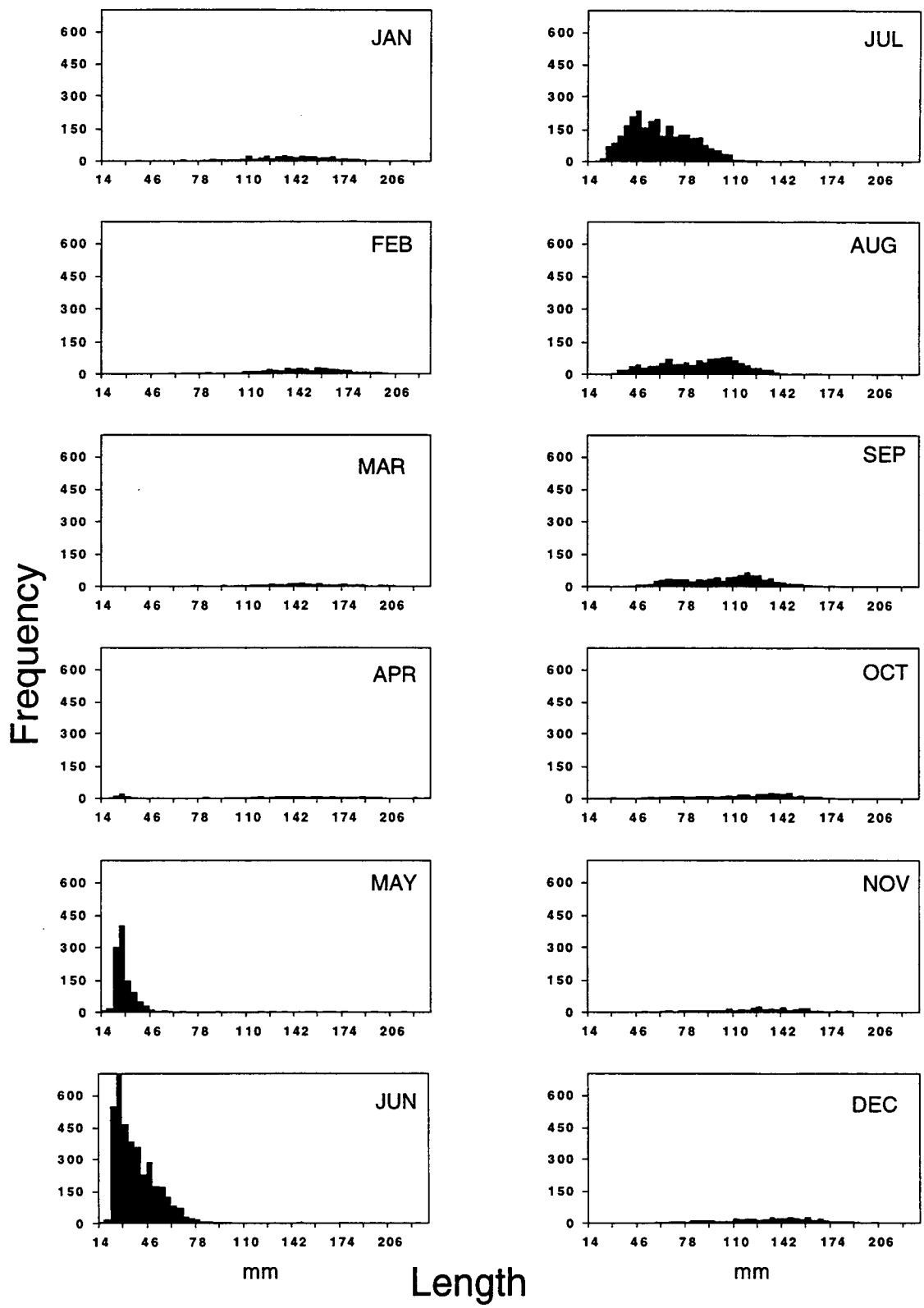

Figure 8 Length distribution of yellowfin gobies by month from 1980 to 1988

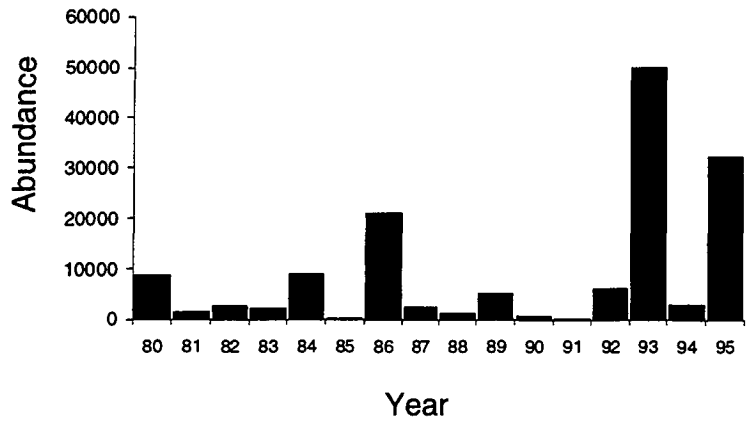

Figure 9 Annual abundance of age–0 yellowfin goby

Table 2 Monthly abundance indices of age–0 yellowfin gobies captured in the midwater trawl from 1980 to 1995. The last column is the annual index, the mean abundance from May to October. The bottom row is the average seasonal abundance from 1981 to 1988.

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Index*
1980		80	245	0	3992	24986	5751	6475	9469	2143	467	109	8803
1981	826	900	0	288	208	2943	1876	2126	587	0	66	443	1290
1982	815	553	78	0	231	5032	5347	2918	1002	965	2323	1264	2583
1983	1813	451	631	0	0	3560	5584	1651	128	1548	217	2006	2078
1984	0	0	0	199	1161	27740	16449	5822	2105	784	474	566	9010
1985	439	216	516	0	0	45	47	1265	57	64	186	0	247
1986	572	319	1226	130	1897	17706	37685	51412	15174	1609	571	4934	20914
1987	2516	709	367	99	0	207	2336	5692	5276	1634	6554	4794	2524
1988	3428	363	50	202	511	750	2078	1391	1442	166	0	57	1056
1989	156	532	324	281	1465	4687	6215	8174					5135
1990		151	388	57	57	183	1519	674	309	296			506
1991		230	136	99	0	0	0	284	495	0			130
1992		0	0	0	11970	9789	7137	5972	2173	746			6298
1993		981	68	301	83326	89922	94465	20933	10199	1631			50079
1994		3293	907	187	337	2264	2568	7996	3627	274			2844
1995	1042	154	0	6525	13286	80857	55060		10643	1852	1390	1746	32339
1981-1988	1301	439	358	115	501	7248	8925	9034	3221	846	1299	1758	

Abundance

Annual abundance of age–0 yellowfin gobies fluctuated more than 10 times (Figure 9, Table 2). It was highest in 1993, next highest in 1995, and lowest in 1985 and 1991. No trend in abundance was apparent. Seasonally, abundance typically peaked during summer, decreased in fall, and recovered somewhat during winter (see Table 2).

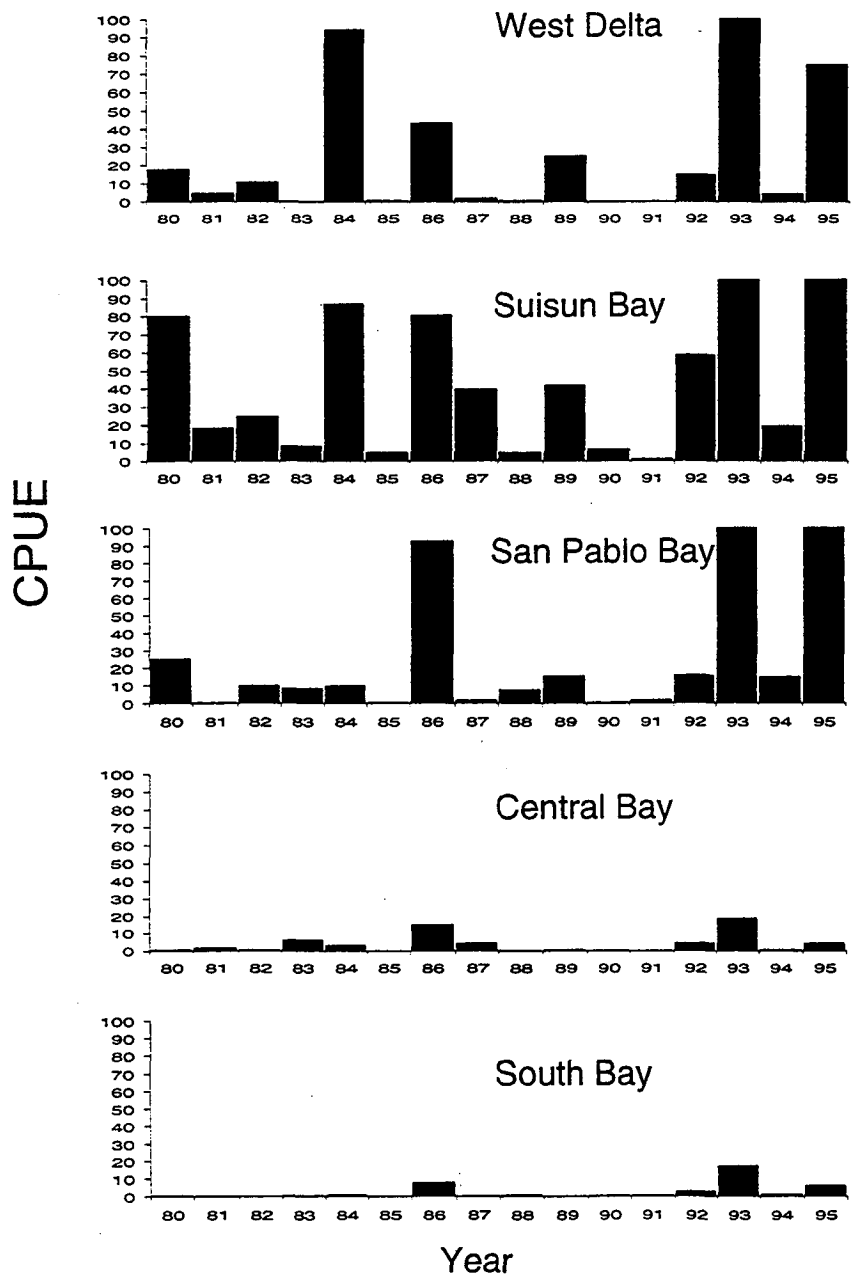

Figure 10 Annual yellowfin goby distribution by region. Values are the average CPUE for May to October.

Distribution

Yellowfin gobies were concentrated in Suisun Bay and the west delta in most years (Figure 10). The CPUE was usually highest in Suisun Bay and lowest in South and Central bays.

Yellowfin gobies moved seasonally between San Pablo and Suisun bays (Figure 11). Highest density occurred in San Pablo Bay in winter, shifted into Suisun Bay in spring, remained there during summer, and returned to San Pablo Bay in November. The CPUE also tended to be highest in Central Bay in fall and winter and in South Bay in winter.

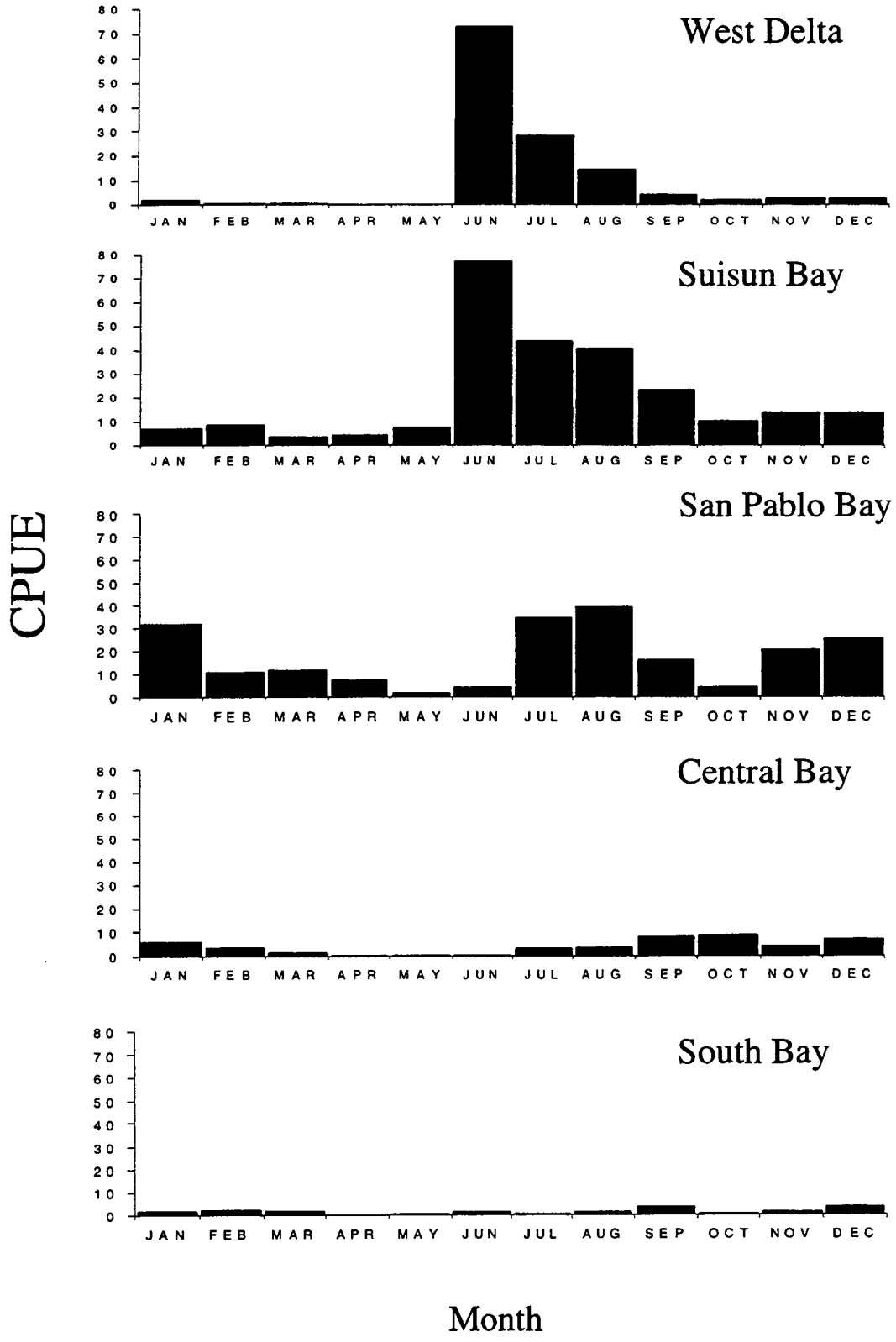

Figure 11 Seasonal yellowfin goby distribution by region. Values are the average CPUEs for 1981 to 1988.

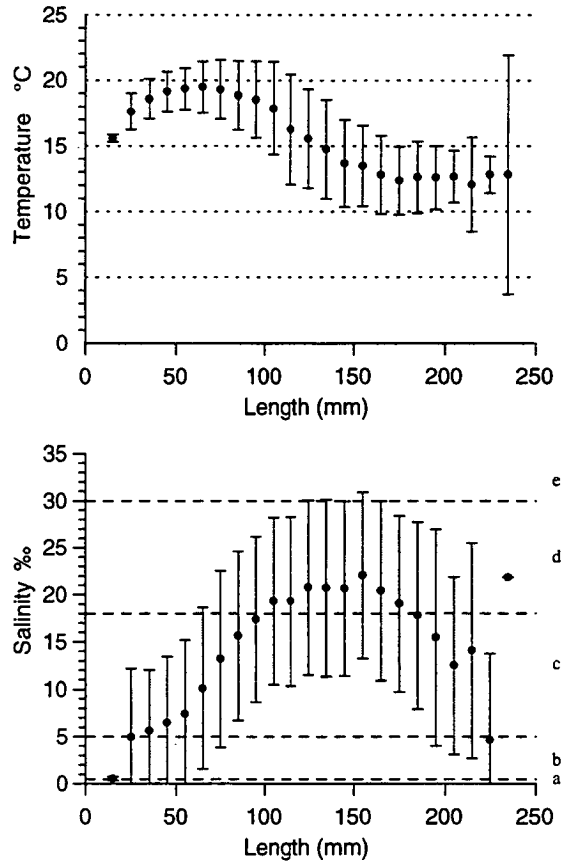

Figure 12 Temperature and salinity distributions of yellowfin gobies by length. The dots are the means and the bars are one standard deviation. The horizontal lines on the salinity graph mark the boundaries of the Venice system ranges: (a) limnetic, (b) oligohaline, (c) mesohaline, (d) polyhaline, and (e) euhaline.

Temperature and Salinity

Yellowfin gobies were collected over broad ranges of salinity and temperature. These ranges increased with size of fish. The smallest fish (20 to 30 mm) were collected at a mean salinity of 4.9‰ and a mean temperature of 19.3 °C; the larger fish (140 to 160 mm) were collected at a mean salinity of 20.7‰ and a mean temperature of 13.7 °C (Figure 12A). For the few fish that were >160 mm the mean salinity decreased with length.

Discussion

Yellowfin gobies are a fast growing, short-lived species whose abundance varied greatly from year to year. Each year was dominated by a year class. Because of the juvenile dispersion upstream, in most years the majority of the younger fish were in the west delta and Suisun Bay and the older fish were in San Pablo Bay.

Despite the fluctuating annual abundance, the seasonal movements followed a consistent pattern. During fall and late winter, females lay their eggs in burrows in the shallows of San Pablo Bay and the eggs hatch approximately 1 month later. The larvae are concentrated near the bottom of the water column (CDFG, unpublished), and are transported upstream by tidal currents (Wang 1986). The young fish begin an

upstream migration in spring. By late fall, the maturing gobies migrate to San Pablo Bay. Their movements to the shallows for spawning make them less susceptible to our sampling and the catch drops in fall. After spawning, the surviving females either leave or remain with the males to guard the eggs (Wang 1986). Most yellowfin gobies die after their 1st year.

Chameleon Goby

Introduction

The chameleon goby is native to the Asian Pacific. It was introduced, presumably in ship ballast, during the 1960s (Brittan and others 1963). It is a marine fish that is only rarely collected in brackish water (Akihito and Sakamoto 1989, Matern and Fleming 1995).

Most larvae appear to reside in the open waters of South Bay (Wang 1986). The pelagic larvae settle to the bottom when they grow to about 15 mm (Dotu 1958, as cited in Wang 1986). They reach sexual maturity in 1 year and may live up to 3 years (Dotu 1958, as cited in Wang 1986), and reach a maximum length of about 110 mm (Eschmeyer and others 1983).

The chameleon goby spawns several times a year from May to September (Wang 1986). The eggs are deposited either on shells (Dotu 1958, as cited in Wang 1986) or on other firm substrates (Wang 1986) and are guarded by the males. Incubation averages 8.5 days (Dotu 1958, as cited in Haaker 1979).

Methods

Otter trawl data were used in the descriptions of length, abundance, distribution, salinity, and temperature. The annual index period was February through August. Fish were not separated into age classes because most of the age–0 fish were collected in late fall and winter, and winter sampling ended in 1989.

Results

Length Frequency

The chameleon goby appears to be short-lived. Each year's catch was primarily made up of a single year class (Figure 13). The smallest gobies (about 20 mm) were collected in late fall and winter, indicating probable late spring and summer spawning. Very few fish appeared to be over 1 year old; the majority were collected near the end of their 1st year and very few were >70 mm. Fish >90 mm were collected between March and April may have been about 2 years old.

Abundance

Abundance varied greatly between 1980 and 1995 (Figure 14, Table 3). No fish were collected in 1980 and abundance was very low from 1981 to 1987. Annual abundance was highest in 1993 and next highest in 1994.

Chameleon gobies were found throughout the year, although the abundance index tended to be highest in December and February (Figure 15). Abundance was lowest in late summer and early fall.

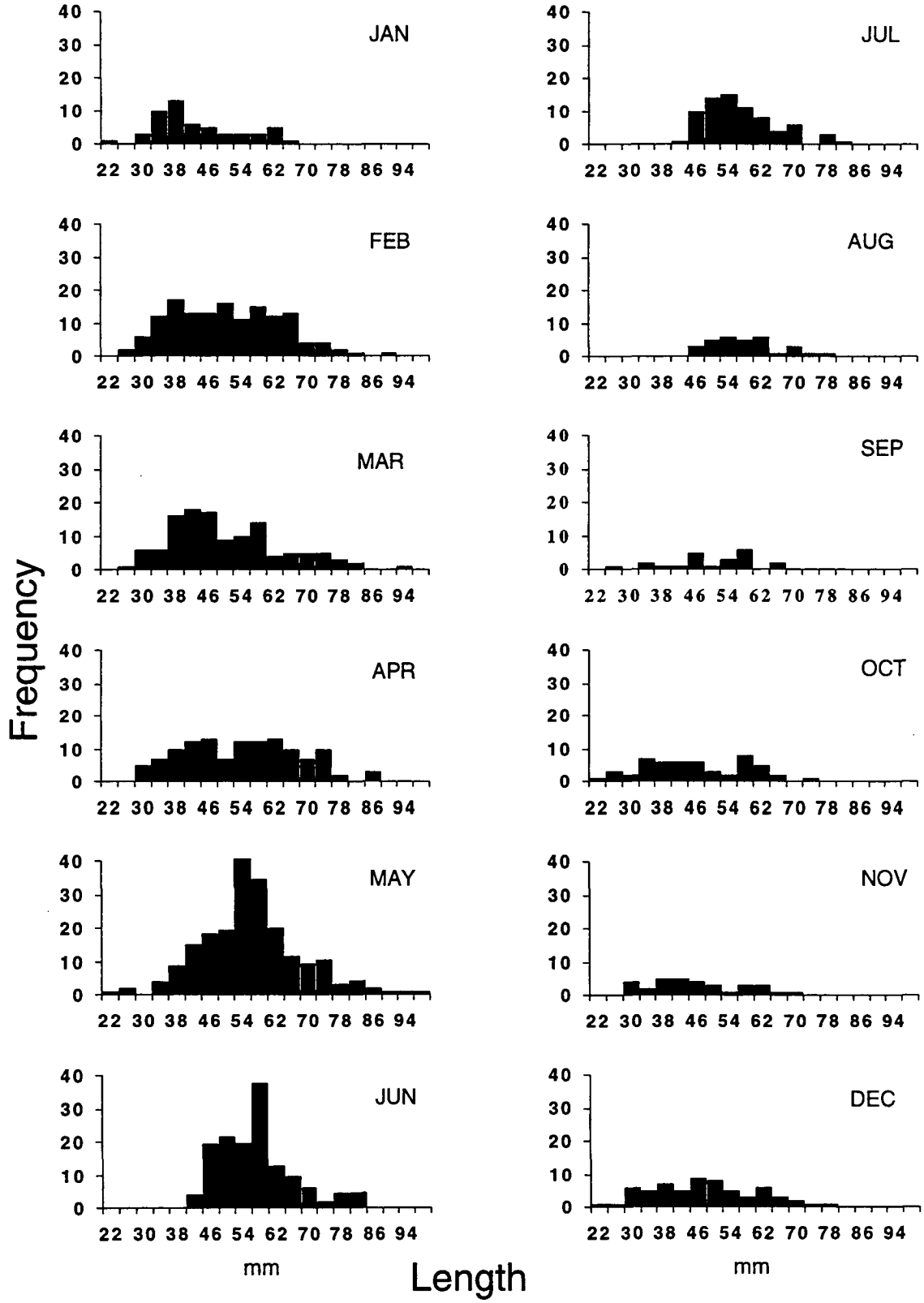

Figure 13 Length distribution of chameleon gobies by month from 1980 to 1988

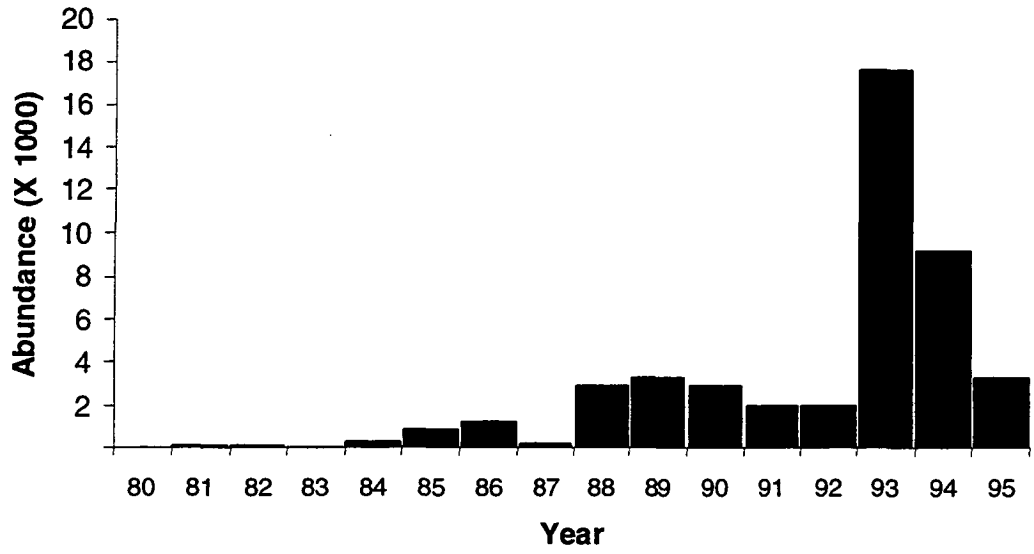

Figure 14 Annual abundance of chameleon goby

Table 3 Monthly abundance indices of chameleon gobies captured in the midwater trawl from 1980 to 1995. The last column is the annual index, the mean abundance from February to October. The bottom row is the average seasonal abundance from 1981 to 1988.

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Index*
1980		0	0	0	0	0	0	0	0	0	0	0	0
1981	1321	0	0	582	0	0	352	0	0	0	0	235	133
1982	0	0	0	0	1057	0	0	0	0	0	0	0	151
1983	170	0	0	290	0	329	0	0	0	235	0	987	88
1984	0	0	882	817	548	215	0	0	0	897	1645	429	352
1985	0	5612	224	380	0	352	0	0	0	480	0	3071	938
1986	0	4046	2657	0	457	1295	449	0	417	274	1242	563	1272
1987	0	523	519	0	0	290	0	0	0	247	5304	6306	190
1988	4106	1865	0	6671	7887	1730	1817	759	0	0	1303	1484	2961
1989	5935	3270	7961	448	2717	4945	1044	2609					3285
1990		1858	6243	737	2804	6979	1359	805	274	0			2969
1991		1640	1387	1233	5209	1004	2057	1132	1421	1758			1952
1992		1505	838	4169	3174	3551	203	308	1611	10377			1964
1993		15693	2777	7254	50714	32649	11315	2729	1157	2467			17590
1994		5406	11356	8588	6983	20208	4275	6766	2565	617			9083
1995	2940	2429	13297	1199	987	0	2193		931	658	0	1408	3351
1981-1988	700	1506	535	1093	1244	526	327	95	52	267	1187	1634	

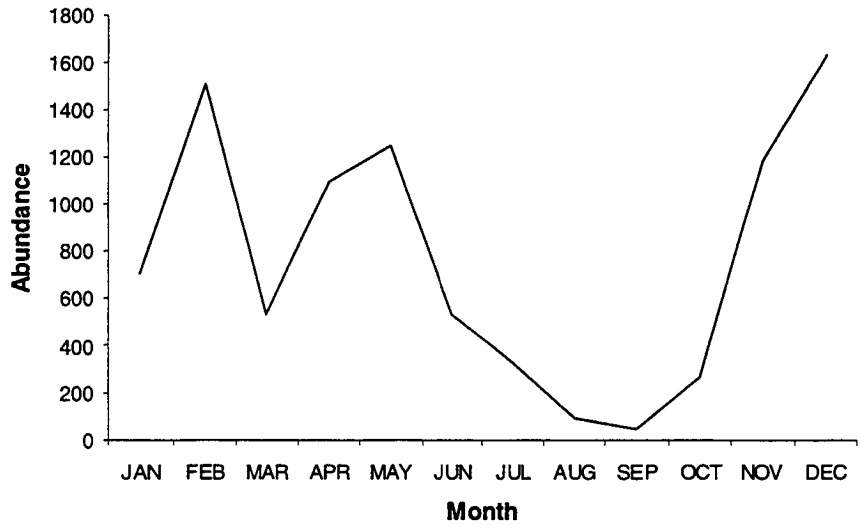

Figure 15 Seasonal abundance of chameleon goby from 1981 to 1988

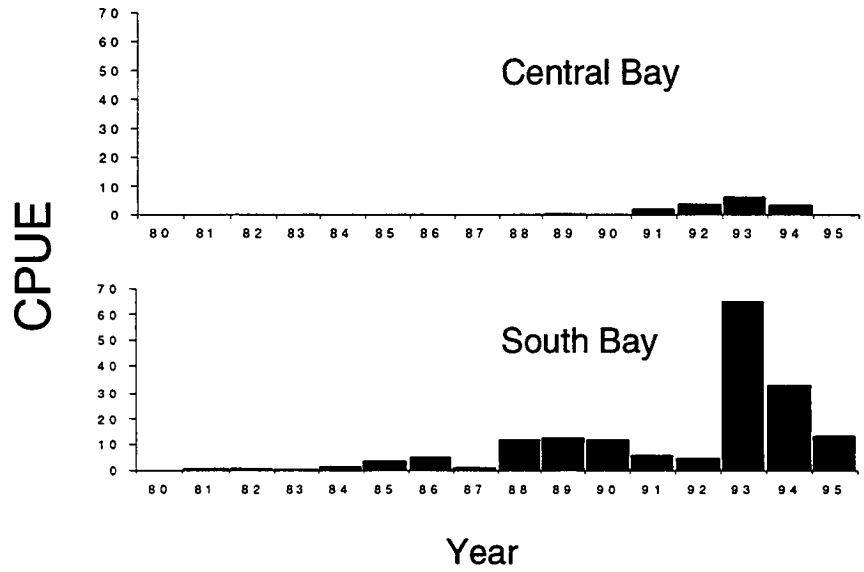

Figure 16 Annual chameleon goby distribution by region. Values are the average CPUE for February to August.

Distribution

From 1981 to 1987, catches of chameleon gobies were sporadic and limited primarily to the South Bay (Figure 16). They were first collected in Central Bay in 1986 and after that became more common there. No seasonal movements between areas were detected.

Temperature and Salinity

Throughout the year, chameleon gobies remained primarily within the polyhaline to euhaline salinity range, with a mean of 27.0‰ (Figure 17). Temperature varied with the season, ranging from 7.1 to 22.5 °C, with a mean of 15.4 °C.

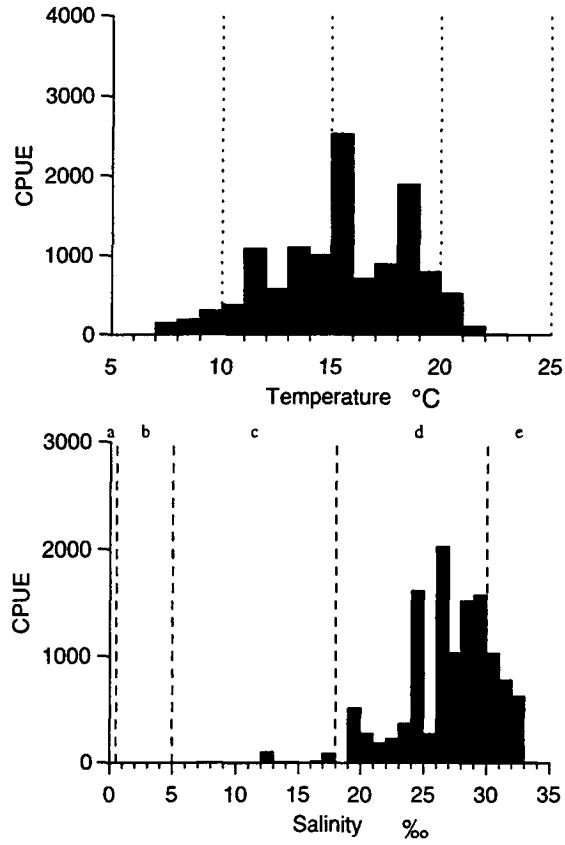

Figure 17 Temperature and salinity distributions of chameleon gobies. The vertical lines on the salinity graph mark the boundaries of the Venice system ranges: (a) limnetic, (b) oligohaline, (c) mesohaline, (d) polyhaline, and (e) euhaline.

Discussion

The abundance and distribution of the chameleon goby increased between 1980 and 1993, although there appeared to be a downward trend after 1993. Juveniles and adults were apparently restricted by salinity to South and Central bays, and only the larvae (Wang 1986) were collected upstream from Central Bay.

Like most other gobies, chameleon gobies are relatively short-lived. The annual decline in the abundance index from June through September is concurrent with the spawning period for this species (Wang 1986). Very few fish older than 1 year were collected, indicating a high post-spawning mortality.

References

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